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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/766,886	01/30/2004	Tatsuya Usami	8001-1190	4182

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EXAMINER	
PAREKH, NITIN	
ART UNIT	**PAPER NUMBER**
2811	

DATE MAILED: 12/14/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/766,886	USAMI, TATSUYA	
	Examiner	Art Unit	
	Nitin Parekh	2811	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *13 October 2005*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-16 and 33-39* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-16 and 33-39* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *30 January 2004* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 1-9, 12-14 and 33-39 are rejected under 35 U.S.C. 103(a) as being unpatentable over in view of admitted prior art (APA) and Lee et al. (US Pat. 6876082).

Regarding claims 1-3, 12 and 13, APA discloses a semiconductor device (Fig. 14-18B) comprising:

- a base layer (501/502 in Fig. 14) comprising a semiconductor substrate
- an interlayer dielectric film (IDF 503/504 in Fig. 14) provided over the base layer, the IDF having Si-H bonds/being ladder-type hydrogenated polysiloxane film (APA: specification page 10),
- silicon carbon nitride/SiCHN/barrier insulating film (507 in Fig. 14; see APA: specification page 10, US Pat. 6417092, Jain et al.) formed over the IDF film
- an interconnection trench lined with a barrier (505 in Fig. 14) comprising a metal Ta film (see APA: specification pages 10 and 11), the Ta contacting the IDF, and

- an electrically conductive film containing copper (Cu) alloy having Cu as a main component (506 in Fig. 14; specification page 3) filling an interior side of the interconnection trench, the conductive film forming a damascene interconnection and the SiCHN contacting the electrically conductive film

(Fig. 14-18b; Specification pages 1-11).

APA further teaches the insulating layer structure comprising:

- lower-layer insulating film
- first silicon carbide/SiCHN/barrier insulating film in contact with the lower-layer insulating film
- first L-Ox/low-k insulating film/IDF in contact with the first silicon carbide/barrier insulating film, the first L-Ox film being ladder-type hydrogenated polysiloxane film, a first SiO2 film/IDF in contact with the first L-Ox film, and
- the IDF and electrically conductive film are each formed in a plurality of layers including the first and second IDF, the barrier diffusion layer, the barrier metal layer and electrically conductive film and the SiCHN is formed so as to cover the electrically conductive film and the IDF film each in a top layer

(see APA: Fig. 14-18b; specification pp. 2-11).

APA fails to teach using a barrier metal nitride film, the barrier metal nitride being non-occluding to hydrogen.

Lee et al. disclose a semiconductor device (Fig. 3) having improved barrier film structure comprising:

- an interconnection trench lined with a laminated barrier structure comprising an outside/lower metal nitride and inside/upper metal film such as tantalum nitride/tantalum (TaN/Ta; 24a in Fig. 3; Col. 7, lines 20- Col. 8, line 50), the TaN contacting the IDF (see 24a and 16/16b in Fig. 3), the TAN being inherently non-occluding to hydrogen, and
- the barrier structure providing inhibited interdiffusion, improved electromigration resistance and improved adhesion

(Fig. 3; Col. 3, line 45 – Col. 9, line 56; Col. 2-10).

It would have been obvious to a person of ordinary skill in the art at the time invention was made to incorporate the barrier metal nitride film, the barrier metal nitride being non-occluding to hydrogen as taught by Lee et al. so that that the adhesion, electromigration resistance and reliability can be improved in the APA.

Regarding claims 4-9, APA and Lee et al. teach substantially the entire structure as applied to claims 1-3 above, wherein the APA (see US Pat. 6417092, Jain et al.) further teaches the SiCHN film having a Si in a range of about 15-40 at.%, C in a range of

about 20-40 at.%, N in a range of about 2-20 at.% and H in a range of about 25-55 at.% (Col. 1, line 65- Col. 2, line 15). Furthermore, the determination of film parameters such as elemental composition/at.%, Si-H/Si-O bond ratio, dopant distribution within the film, etc. etc. in chip packaging and interconnect technology art is a subject of routine experimentation and optimization to achieve the desired final properties including dielectric constant, hardness/porosity, etch resistance, etc.

Regarding claim 14, APA and Lee et al. teach substantially the entire structure as applied to claims 1 and 2 above, wherein Lee et al. teach the TaN/Ta structure further including:

a) the TaN/metal nitride film being provided between the IDF the electrically conductive film containing Cu as a main component element and the Ta/metal film is provided between the electrically conductive containing Cu as a main component element and the TaN/metal nitride film (see Col. 7 and 8), and

b) the TaN/metal nitride film having a nitrogen concentration such that the nitrogen concentration varies from about 50 at % (stoichiometric ratio) to about 16 at. % (Ta:N of about 1:0.2) to provide the desired improved electrical performance and electromigration resistance (Col. 7-9).

Furthermore, the determination of film parameters such as elemental composition/at. %, metal/nitrogen ratio, Si-H/Si-O bond ratio, dopant distribution within the metal nitride film, IDF, etc. etc. in chip packaging and interconnect technology art is a subject of routine experimentation and optimization to achieve

the desired final properties including contact resistance, electromigration resistance, dielectric constant, hardness/porosity, etch/oxidation resistance, etc.

It would have been obvious to a person of ordinary skill in the art at the time invention was made to incorporate the metal nitride film having nitrogen concentration of not less than 15 atm % but less than 40 atm % as taught by Lee et al. so that the electromigration resistance/diffusion barrier and electrical performance/reliability can be improved in the APA and Lee et al's device.

Regarding claims 33-39, APA and Lee et al. teach substantially the entire structure as applied to claims 1-9 and 12-14 above, wherein Lee et al. further teach the metal nitride of the barrier structure being titanium nitride/TiN (Col. 7, line 9).

3. Claims 10 and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over APA and Lee et al. (US Pat. 6876082) as applied to claims 1-5 above, and further in view of Xu et al. (US Pat. 2003/0077916).

Regarding claims 10 and 11, Jain et al. and APA teach substantially the entire structure as applied to claims 1-5 above, except the SiCN film having oxygen (O) being in a range of about 0.5-5.0 at.%.

Xu et al. teach a silicon and carbon containing barrier film/SiC further comprising oxygen and nitrogen doped film having Si, C, H, N, O/SiCHON composition wherein the oxygen content about less than 10 at.% (sections 0023-0025).

Furthermore, the determination of film parameters such as elemental composition/at.%, Si-H/Si-O bond ratio, dopant distribution within the film, etc. etc. in chip packaging and interconnect technology art is a subject of routine experimentation and optimization to achieve the desired final properties including dielectric constant, hardness/porosity, etch/oxidation resistance, etc.

It would have been obvious to a person of ordinary skill in the art at the time invention was made to select the SiCN film having the oxygen being in a range of about 0.5-5.0 at.% as taught by Xu et al. so that the desired elemental distribution among silicon, carbon, nitrogen and oxygen to provide the optimized etch/oxidation resistance, diffusion barrier and dielectric constant can be achieved in the APA and Jain et al's device.

4. Claims 15 and 16 are rejected under 35 U.S.C. 103(a) as being unpatentable over APA and Lee et al. (US Pat. 6876082) as applied to claims 1 and 2 above, and further in view of Noguchi et al. (US Pat. 2002/0042193).

Regarding claims 15 and 16, APA and Lee et al. teach substantially the entire structure as applied to claims 1 and 2 above, except the electrically conductive film containing Cu

as a main component element is a Cu alloy film containing Si and the Si content is highest on a top surface of the electrically conductive film and gradually decreases with increasing depth in the direction of a bottom surface.

Noguchi et al. teach a copper interconnect structure having Cu as a main component within a trench (see Fig. 67) wherein the Cu/Cu alloy contains Si which is distributed within the Cu/Cu alloy plug such that the Si content is highest on a top/around top surface (see Si content at d=10-60mm in Fig. 67 for NH3/H2 plasma; sections 0340 and 0342) and gradually decreases with increasing depth (see Si content at d=90-300mm in Fig. 67 for NH3/H2 plasma; sections 0340 and 0342) in the direction of a bottom surface.

It would have been obvious to a person of ordinary skill in the art at the time invention was made to incorporate the Cu alloy film containing Si such that the Si content is highest on a top surface and gradually decreases with increasing depth in the direction of a bottom surface as taught by Noguchi et al. so that the Cu alloy impurity level can be reduced and the surface cleanliness can be improved the APA and Lee et al's device.

Response to Arguments

5. Applicant's arguments with respect to claims 1-16 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

6. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nitin Parekh whose telephone number is 571-272-1663. The examiner can normally be reached on 09:00AM-05:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Eddie Lee can be reached on 571-272-1732. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9318.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAN or Public PAG. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAG system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Nitin Parekh

Nitin Parekh

PRIMARY EXAMINER

NP

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12-07-05